AERONET Quarterly-July 05
Version 2 Processing Announced

Dear colleagues, collaborators, data users and interested parties:

I'm very happy to announce the release of AERONET Version 2 (**V2**) for the sun measurements (**V2S**). This will be followed, probably in September, with the addition of **V2** for the inversion retrievals (**V2R**). Our philosophy towards the processing algorithms has not changed, that is we are using published community accepted algorithms and data sets to process the direct sun and sky radiance data…with a caveat as described later. If you, the users, prefer to make your own corrections, we also provide the total optical depth as well as the component optical depths for each spectral measurement in **V2S**. If you find an error or discrepancy in the **V2S** database, please contact me immediately so that I can alert the community using the data and we can solve the problem quickly.

The ground rules:

All **V2** processing will be retroactive for the entire AERONET database dating back to 1993. The old 'AERONET Version 1' (**V1**) processing will continue in parallel through at least December 2005 to insure continuity for those wishing to complete data sets or investigations. Access, availability and website appearance will remain exactly as in the past. The **V2** data are available from the same website (http://aeronet.gsfc.nasa.gov) as are the complete and updated **V1** database. Both data sets are clearly labeled. Until **V2R** products are operational, the only retrievals that will be available are the legacy products based on **V1** inputs. All climatologies have been recomputed thus providing a **V1** and **V2** AOD and water vapor climatology. Although the direct sun **V2S** products are inputs to the retrievals there will be no mixing **V2S** with **V1R** products.

Quality controlled data, levels 1, 1.5 and 2.0, are available in **V2S**.

V2S Summary-what is the net effect?

Please refer to Table 1 and 2 for a **V1** and **V2S** comparison and the discussion below. Table 3 with references is the complete description of the changes implemented in **V2S**.

Ozone: We replaced London's global average O_3 climatology with TOMS 30 year climatology. In all but extreme cases this is a difference of less than 0.003 AOT at 675 nm. Other affected bands are less.

NO_2: Caveat: NO_2 is optically present in very small quantities in the stratosphere but is highly variable in the lower troposphere being highest in urban/industrial regions due to fossil fuel combustion. We ignored this absorption in **V1** due to lack of widespread observations. **V2S** uses a 3 yr.

monthly climatology from SCIAMACHY. Although the SCIAMACHY data are not fully independent observations, comparisons to GOME and ground-based observations indicate the SCIAMACHY data are relatively accurate (but we feel slightly underestimate the measured concentration) and thus merits inclusion in our correction scheme. Net effect ~ 0.01 at 380 nm in urban areas but globally is <0.003 depending on wavelengths between 340 nm through 500 nm.

Rayleigh: The algorithms are only slightly improved to account for polarization effects. The overall difference between **V1** and **V2** is insignificant, maximum of 0.003 at 340 nm at sea level.

Air Pressure: This input to the Rayleigh algorithms is extremely important especially for the UV and blue bands. In **V1** we used a constant pressure of 1013.25 adjusted by elevation of the station. For high elevation sites and moderate elevation continental sites, the calculated 'station pressure' was sometimes off by more than 20 hPa resulting in miss-correcting AOD at 340 nm by more than 0.015.

The NCEP/NCAR Reanalysis 6-hourly data access base provides global mean sea-level pressure and standard pressure level heights (1000, 925, 850, 700, 600 hPa). These pressure level data are used to interpolate and fit the pressure at the station elevation. Our analysis shows that 95% of all observations are within 1 hPa measured station pressure and difficult sites such as Mauna Loa, owing to it height, had 95% of all observations within 2 hPa of recorded station pressure. NCEP air pressure inputs for Rayleigh corrections represents the most significant improvement in **V2S** processing and, because of ready access to the data, is highly recommended for sun photometry in the absence of measured station pressure.

The NCEP/NCAR Reanalysis 6-hourly data has a 2.5 by 2.5 degree spatial resolution and are normally available after a four to five week delay. Thus we compiled a monthly climatology (from a 50 year record) to use for the real time level 1 and 1.5 data. Histograms of the climatology to measured station pressure show 95% of observations less than 2 hPa deviation for Goddard and 4 hPa at MLO. The 6-hourly will replace 1, and 1.5 as it becomes available and will always be used for level 2.0 data.

$H_2$0: LBLRTM was used to compute the A and B coefficients for all 940 filters where the filter function was available to more accurately account for water vapor absorption. The resulting water vapor retrievals showed a decrease of approximately 13 to 19% from **V1** retrievals. This is in agreement with published biases of Schmid and comparisons to ~7000 GPS retrievals at GSFC showed a bias of ~2% thus suggesting great improvement over **V1**. We will now support a quality assured product (level 2.0) for water vapor.

Measured filter functions for each filter in the network, including the 940 water vapor absorption band, were consistently available back to 1997 and only about 50% of the 940's prior to that. Because we require the filter function to determine the A and B coefficients, only water vapor retrievals from those instruments with measured filter functions will be raised to level 2. Prior to 1997, depending on circumstances, batch filter function was determined from a measured subset and was applied to each instrument's 940 filter to compute coefficients A and B, calibration coefficients and finally the column integrated water vapor. This effort will only result in level 1.5 data. As we continue to uncover more spectral curves from the past or measure the filter function (we have most of the filters in the AERONET museum), we will be able to promote more of the early data to level 2. The process continues…

Due to temperature dependence and water vapor absorption in 1020 nm filters the resulting AOD is slightly more uncertain compared to other channels. Thus we decided to extrapolate from 440 through 870 nm to 940 nm to estimate the AOD component rather than interpolate between 870 and 1020 nm as in **V1**.

Water vapor absorption is removed from the 1020 nm and 1640 nm filters based on the improved H_20 algorithm.

Trace Gasses: CH_4 and CO_2 optical depths are computed for each filter function using profiles from US 1976 standard atmospheric model. Absorptions are removed from the 1640 nm filter according to the NCEP height-pressure relationship. This replaces the standard air pressure vs height algorithm of **V1**.

The corrections to the AOD retrievals, as with the water vapor retrievals, uses individual filter functions in our analysis available since 1997, prior to that batch average filter functions were applied because transmittances were not measured for all filters. Given our improved filter tracking and computational horsepower in **V2S** we are now convolving each spectral band pass to the solar spectrum, evaluating O_3 and NO_2 absorption cross sections absorption spectra at 0.1 nm resolution. Compared to the previous center wavelength analysis this makes a difference of only a few thousandths and overall is likely randomly distributed. Batch averaged filter functions are processed identically and can be raised to level 2 status.

Optical Airmasses: We have implemented optical airmasses in our algorithms for Rayleigh, H_2O, O_3 as detailed in Table 3.

What is yet to come in V2S?

Three additional products will come on line for **V2S:**

- SeaPRiSM ocean leaving radiances driven by Giuseppe Zibordi,
- the τ_f and τ_c and eta from AOD observations developed by Norm O'Neill
- direct normal spectral irradiances

These will be released and announced over the next few weeks as we evaluate the new algorithms and determine the screening criteria for level 2 quality assurance. Also under evaluation for **V2S** will be cloud screening options and the potential for corrections from station observations.

Acknowledgments:
Development of **V2S** has been a time consuming effort requiring meticulous research, analysis and reanalysis by the following team members. Great kudos goes to Norm O'Neill for advocating NO_2 corrections for years and providing the initial correction efforts. Ilya Slutsker has written and implemented a battery of programs to populate a new expanded and flexible database that everyone utilizes but few appreciate the intricacies. Many thanks also to David Giles who creatively implemented the ancillary data sets with skill and insight and always managed to provided the web based solutions to keep the rest of us in the game. Alexi Lapuston willingly provided LBLRTM modeling for our water vapor analysis. Alexander Smirnov demonstrated his masterful meticulousness in every phase of **V2S:** algorithm research, development, implementation and critical analysis. Lastly Tom Eck's great insight into the algorithms and the data combined with his broad perspective allowed a deep and thorough evaluation of the **V2S** database that we can all confidently use for our scientific research.

Cheers,
Brent Holben

Table 1. Algorithm modifications from Version 1: Rayleigh, Solar flux, NO_2, O_3, CH_4, H_20, CO_2

Parameter	Version 1	Version 2
Rayleigh optical thickness	Edlen 1966	Bodhaine et al. 1999
Air Pressure	1013.25 mb & height eq.	NCEP interpolated pressure ht
Solar Flux	Neckel and Labs 1981; and Frohlich and Wehrli 1981	Woods et al. 1996
Ozone	London et al. 1976	TOMS O_3 1979-2004
NO_2	None	Schiamachy monthly climatology
Water Vapor Content	Bruegge et al. 1992; Reagan et al. 1992	Michalsky et al. 1995; Schmid et al. 1996
Water vapor correction for AOD (1020 nm)	None	LBLRTM

Table 2: Spectral Corrections/components

Standard Wavelengths (nm)	**Version 1**	**Version 2**
340 (2nm)	Rayleigh, O_3	Rayleigh, NO_2, O_3
380 (4 nm)	Rayleigh	Rayleigh, NO_2
440 (10 nm)	Rayleigh	Rayleigh, NO_2
500 (10 nm)	Rayleigh, O_3	Rayleigh, NO_2, O_3
675 (10 nm)	Rayleigh, O_3	Rayleigh, O_3
870 (10 nm)	Rayleigh	Rayleigh
940 (10 nm)	Aerosol: Interpolate 870 to 1020	Aerosol: Extrapolate 440 thru 870 to 940
1020 (10 nm)	Rayleigh	Rayleigh, H_2O
1640 (25 nm)	Rayleigh	Rayleigh, H_20, $C0_2$, CH_4
Sea-Prism Wavelengths (nm)	**Version 1**	**Version 2**
412 (10 nm)	Rayleigh	Rayleigh, NO_2
555 (10 nm)	Rayleigh, O_3	Rayleigh, NO_2, O_3

Table 3: **AERONET Version 2 Direct Sun Algorithm**

Ancillary Data Set Corrections	Data Product	Spatial Resolution	Temporal Resolution	Source
NO_2 *[Reference 1]*	Total column concentration [molec/cm^2]	Global: 0.25 x 0.25 degrees resolution	Monthly climatology (2003-2005)	ESA SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY (SCIAMACHY)
O_3 *[Reference 2]*	Total column concentration [Dobson Units]	Global: 1 x 1.25 degrees resolution	Monthly climatology (1978-2004)	NASA Total Ozone Mapping Spectrometer (TOMS): Earth Probe and Nimbus
Pressure *[Reference 3]*	Station pressure [hPa] derived from standard pressure level heights [m] and sea-level pressure by using quadratic fit in logarithmic space	Global 2.5 x 2.5 degrees resolution Six pressure level heights: sea-level, 1000, 925, 850, 700 600 hPa	Use 6-hourly when available and default to monthly climatology (1993-2004)	NCEP/NCAR Reanalysis

Corrections	Explanation	Implication
O_3 Absorption *[Reference 4]*	Integration of ozone spectroscopy and fitted to filter function for each wavelengths to obtain ozone absorption coefficients.	Improved ozone wavelength-dependent absorption correction
NO_2 Absorption *[Reference 5]*	Integration of NO_2 spectroscopy and fitted to filter function for each wavelength to obtain NO_2 absorption coefficients.	Improved NO_2 wavelength-dependent absorption correction
CO_2 *[Reference 6]*	Constant value of 0.0089 at standard atmospheric pressure and temperature; adjusted by P/P_o.	Affects extended wavelength instruments (e.g., channel 1640nm)
CH_4 *[Reference 7]*	Constant value of 0.0036 at standard atmospheric pressure and temperature; adjusted by P/P_o.	Affects extended wavelength instruments (e.g., channel 1640nm)
Filter Functions *[Reference 8]*	Filter functions have been updated for instruments after 1997.	Improved data quality.
Rayleigh Optical Air Mass Formula *[Reference 9]*	Updated Kasten 1965 to Kasten and Young 1989.	Very small differences in air mass calculations at high solar zenith angles.
Ozone Optical Air Mass Formula *[Reference 10]*	Updated to Komhyr et. al. 1989.	The ozone layer is no longer fixed at 22km. The ozone layer height is adjusted by latitude to provide a more accurate representation of the ozone height layer.
Water Vapor Optical Air Mass [Reference 11]	Implement Kasten 1965.	Account for the water vapor optical air mass.
Water Vapor A and B Coefficients Recalculated *[Reference 12]*	Water vapor transmission (T_w) was modeled as $T_w = \exp[-A(mw)^B]$ using the radiative transfer code from Alexei Lyapustin. Constants A and B are unique to the particular filter and w is the vertical column water vapor content.	Improved water vapor calculations by up to 20%.
Rayleigh *[Reference 13]*	Rayleigh equation suggested by Bodhaine et. al. (1999)	<0.001-0.007 change in the τ_R depending on latitude and elevation.
H_2O *[Reference 14]*	Absorption optical depth computed for channels 1020 and 1640nm using instantaneous water vapor calculation (derived from the channel 940nm).	Affects channels 1020 and 1640nm.
Earth-Sun Distance *[Reference 15]*	The effective V_o is calculated using the earth-sun distance correction.	Improved calculation of the effective V_o for each wavelength.

References

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